1997 FRY EMERGENCE

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. M96-6

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ABSTRACT

The fry emergence trapping project was conducted in Reach 2 of the Nechako River for the eighth consecutive year in 1997. Emergent chinook fry (*Oncorhynchus tshawytscha*) were sampled by four Inclined Plane Traps (IPTs) at km 19 of the Nechako River from March 8 to May 20, 1997. Subsamples of the daily chinook catches were measured and weighed. Temperature and flow rates were recorded at the sampling site. The date by which 50% of fry had emerged was April 30 (862 Accumulated Thermal Units). There were two peaks of emergence (number of fry counted), one centered around April 18 and the second centered around May 2. The second peak was composed almost entirely of chinook from IPT 4 along the right margin and was coincidental with increased flows from a forced release. The emerging fry population was estimated from the proportion of the flow sampled by the IPTs and from mark-recapture trials. The index of emergence for 1997 was 1,211,894 chinook, equivalent to an emergence success of 101 %. This extreme number probably reflects the inability of the method to account for increased water flows, as previous years indices of emergence success have ranged from 42.2 to 56.7 %. Mark-recapture trials resulted in population estimates ranging from 67,071 to 798,432, equivalent to emergence success estimates of 61 to 66%.

The condition of emergent chinook in 1997 was similar to that of previous years. Chinook from the margin traps tended to be slightly heavier than those from the mid-channel, and chinook which were sampled at night were smaller and lighter than those sampled during the day. The regressions of fry size versus time yielded very small positive slopes, indicating that fry which emerged in May were slightly larger than fry which emerged in March. The incidental catch of the IPTs was slightly different from previous years in that lake trout (*Salvelinus namaycush*) were observed in 1997. Overall, the results from the 1997 fry emergence trapping program indicate that the quality of the incubation environment in the upper Nechako River does not show any degradation from previous years.

INTRODUCTION

The main objective of the chinook (*Oncorhynchus tshawytscha*) fry emergence trapping project on the Nechako River is to develop an index of fry emergence which may be used to monitor the incubation environment of the river. While the index calculated is indicative of the population processes, it is not a true estimate of the population. However, large deviations in the index from year to year may serve as an indication of a change in the quality of the incubation environment of the Nechako River. The project also includes monitoring the condition of fry by recording morphometric data, as sudden changes in fry condition may indicate a change in the quality of the incubation environment of the Nechako River. The Nechako Fisheries Conservation Program (NFCP) initiated this monitoring project in 1990, and it has been conducted each year since.

In 1990 and 1991 there were forced spills from the Nechako Reservoir during the period of emergence, but from 1992 to 1996 flow conditions were very consistent during this period. A forced release during the emergence period in 1997 provided an opportunity to assess the effect of the increased flows on the index and estimate of emergence success.

METHODS

Study Site

Four 2 x 3 Inclined Plane Traps (IPTs) were installed near Bert Irvine's Lodge 19 km downstream from Kenney Dam (Figure 1). The traps were suspended from a cable strung across the river channel. Temporary cable anchors were designed and constructed on site.

The position and location of the traps were the same as in the previous years except for 1990 when they were positioned differently at the same site. The four traps were installed across the river channel, one on each river margin (IPTs 1 and 4), and two mid-channel (IPTs 2 and 3).

The trap located on the left margin (IPT 1) was approximately 15 m from the shore with a 27 m diversion wing angled from the inshore edge of the trap to the shore 22 m upstream. The trap positioned on the right margin (IPT 4) was approximately 4 m from the shore with an 9.6 m diversion wing angled from its inshore edge to the shore 9 m upstream. The margin traps rested on the river bed, in approximately 0.5 m of water. Operation of the traps started on March 7, was discontinued due to ice from March 12 to March 15, and then continued until May 20, 1997. As flows increased the margin traps were moved shoreward to maintain correct depth and area sampled. However, IPT 1 was located next to a wide bench which became inundated as the flows increased after April 30. The flooded bench was too shallow for the IPT so the wing was extended with panels or sandbags to prevent fish passage around the trap. The average area sampled by the margin traps from March 7 to May 20 was 1.5 m^2 for IPT 4 and 3.5 m^2 for IPT 1. However, by May 19, 1997 IPT 1 was sampling 4.8 m^2.

Nechako River - Physical Data

Mean daily water temperatures were measured by Water Survey of Canada (WSC) at the study site (WSC station # 08JA017). Daily water temperature data from the peak of spawning in September 1996 were used to estimate the probable time of emergence (Wangaard and Burger 1983; March and Walsch 1987) and hence the timing of the sampling. Daily flows were recorded at the study site and at Skins Lake Spillway (WSC station # 08JA013), and are reported as preliminary data.

Sampling Program

The IPTs and wings were cleaned of debris as necessary and the catches sampled twice a day, morning and evening. Water temperatures and staff gauge measurements were recorded daily. All species of fish found in the traps were counted. A subsample of a maximum of ten chinook per trap were anaesthetized and measured to the nearest 1.0 mm (fork length) and to the nearest 0.01 g (wet weight) each sampling period and released downstream of the traps. Bams' (1970) development index K_D was calculated for the measured fry:

$$K_D = \frac{10 \sqrt[3]{\text{weight in mg}}}{\text{length in mm}}$$

Index of Fry Emergence

The index of fry emergence was calculated using daily catches, flows in the Nechako River below Cheslatta Falls and the volume sampled by each trap. The flow in the Nechako River below Cheslatta Falls was available as preliminary data from Water Survey of Canada. The volume of discharge sampled by all traps was determined by measuring the cross sectional area of the trap mouth and the average of velocity at three points across the mouth of each IPT. In addition, the volume of discharge sampled by the two margin traps was estimated as the sum of the discharge through the IPT and the discharge diverted by the diversion wings. Wing discharge was estimated by measuring the upstream cross sectional area created by the diversion wing, and by recording several velocities along a line perpendicular to the shore extending from the upstream edge of the diversion wing to the point opposite the junction of the trap and the downstream end of the diversion wing. Velocity was measured with a Swoffer flow meter and measurements were taken every second day when possible. The total number of emerging chinook moving downstream past the IPTs was estimated from the proportion of discharge sampled by each IPT as follows:

(1) $N_i = n_i (V_i / vi)$

where N_i = expanded number of fish, n_i = number of fish observed, V_i = total river flow, v_i = flow through trap, and i = the *ith* sampling date.

Because statistical independence among IPTs could not be assumed, a combined estimate was calculated for each day. This estimate, which constitutes the index of fry emergence, was the sum of all four IPTs' estimated catches expanded by the water volume filtered by each IPT. It was equivalent to an estimate weighted by the volume filtered:

(2) $$\frac{\Sigma (N_i * v_i) \text{ for all traps}}{\Sigma (v_i \text{ of all traps})}$$

As the sampling program progressed in the season, the risk increased of including already emerged fry, as opposed to emerging fry, in the calculation of the fry emergence index. Already emerged fry may have established residence along the banks in the vicinity of the IPTs, and their inclusion in the calculation was judged to be undesirable, as it would overestimate the index (some fry could be captured and counted twice or more). A more conservative approach was to base the index of fry emergence only on fry which have just emerged from the substrate.

The date at which post-emergent fry started to make a significant contribution to the number of fry caught in the IPTs was inferred from examination of the variance in wet weight. This was based on the assumption that already emerged fry have started to feed, and are thus heavier than emerging fry. Their pooling with emerging fry should result in an increase in the variance in wet weight of fry caught in the IPTs. The cutoff date was set at the point where the variability in pooled wet weights was significantly affected by the addition of the next day's samples, and determined by an F-test ($P < 0.05$). The mean pooled wet weight of all the chinook fry sampled to this date plus one standard deviation was considered to be the upper limit of mean wet weight of newly emergent fry. In order to separate growing fish from emergent fry after the cutoff date, the proportion of fry subsampled that were smaller than the limit was determined. For each day after the cutoff date, the daily index of emergence was multiplied by this percentage. For example, if 50% of the fish subsampled were smaller or equal than the upper limit, 50% of the catches after the cut-off date were used in the calculation of the index of fry emergence.

Estimates of Emergence Success

The numbers of chinook salmon spawning above the study site (river sections 1, 2 and half of section 3 - section 3A) were estimated from the Nechako River spawner enumeration data (unpublished data, DFO). The percent distribution of spawners in these river sections was multiplied by the total Area-Under-the-Curve (AUC) estimate of the total number of spawners in the river.

To estimate the number of chinook eggs deposited upstream of the traps, the total number of spawning females was taken to be one half of the population above the study site. A mean fecundity of 5,769 eggs per female was assumed, based on data from Jaremovic and Rowland (1988) on Nechako chinook (N = 8, standard deviation = 869).

Trap Efficiency

The index of the number of emergent fry relies on the accuracy of the assessment of the proportion of the population sampled by the IPTs. It is based on the proportion of the total river flow sampled by the traps. Another method of estimating fry abundance is to calculate trap efficiency through mark-recapture trials. Three such trials were conducted on April 7, May 2 and May 11, 1997. Chinook fry caught in the IPTs were held in a live box for a maximum of four days until numbers were large enough for a mark-recapture release. The fry were then counted, transferred into an aerated staining container, stained with Bismark brown and kept for 2 hours. The stained fry were transferred to transport containers and any mortalities were noted and subtracted from the total released. Fry were released at dusk at km 18.3 (0.5 km upstream of the IPTs). The number of marked chinook recaptured in each trap was noted along with the total catch (marked and unmarked). The time between mark-recapture trials was sufficient to ensure that previously marked fish would not bias the next trial. Trap efficiency was calculated as the ratio of the number of recaptured fry to the number of released fry. The estimated population was derived from the total number of chinook fry counted over the sampling period divided by the trap efficiency.

Statistical Analyses

The influences of time of day and trap location on the biological variables (fork length, wet weight, and K_D) were determined through factorial ANOVAs. T-tests were used to test the effect of trap position, and LSD tests were used for *a posteriori* testing of the effect of time of emergence. Linear regressions were used to determine the influence of emergence date on some of the fry physical parameters (length, weight and development index).

The increases in fork length (FL) and wet weight (WW) over the trapping period were determined by calculating the average FL and WW of chinook caught during the first two days of sampling (March 8-9, N = 35) and comparing this value with the average FL and WW of chinook caught during the last two days of the program (May 19-20, N = 100).

A Friedman Two-Way Anova and Wilcoxon Matched-Pairs Signed-Ranks tests were performed to compare the composition of the incidental catch to that of previous years.

RESULTS

Nechako River - Physical Data

Mean daily water temperatures and Accumulated Thermal Units (ATUs) from September 11, 1996 (peak spawning period) to May 20, 1997 are provided in Figure 2. During the incubation period, the mean daily water temperatures ranged from 0.1 °C (in December 1996 and January 1997) to 14.5 °C (September 1996). The theoretical chinook peak emergence value of 1,000 ATUs occurred on May 24, 1997.

The releases from Skins Lake Spillway and the flows measured below Cheslatta Falls from March 1 to May 31, 1997 are shown in Figure 3. Flows were steady at approximately 60 m^3/s from March 1 to April 16. A series of incremental increases in releases from the Nechako Reservoir began May 1, and flows continued to increase through the remainder of the sampling period. By the end of May, discharges at km 19 had reached 191 m^3/s.

Fry Emergence

Trap results

The distribution of chinook 0+ catches among the four IPTs is summarized in Table 1. Of the 33,268 chinook fry sampled, 26,735 (80 %) were sampled by the traps along the margins, and the right margin trap (IPT 4) accounted for 63 % of the total (Figure 4). Most (95 %) of the chinook emerged at night. There were bimodal peaks of emergence in 1997, with 26 % of the chinook counted between April 12 and April 25, and 49 % counted between April 25 and May 11 (Figure 5). The second peak was due to IPT 4 predominantly.

Figure 2
Mean Daily Water Temperature and ATUs from the Peak of Chinook Spawning (September 11, 1996) Recorded at Irvine's Lodge (km 19) in Reach 2 of the Nechako River

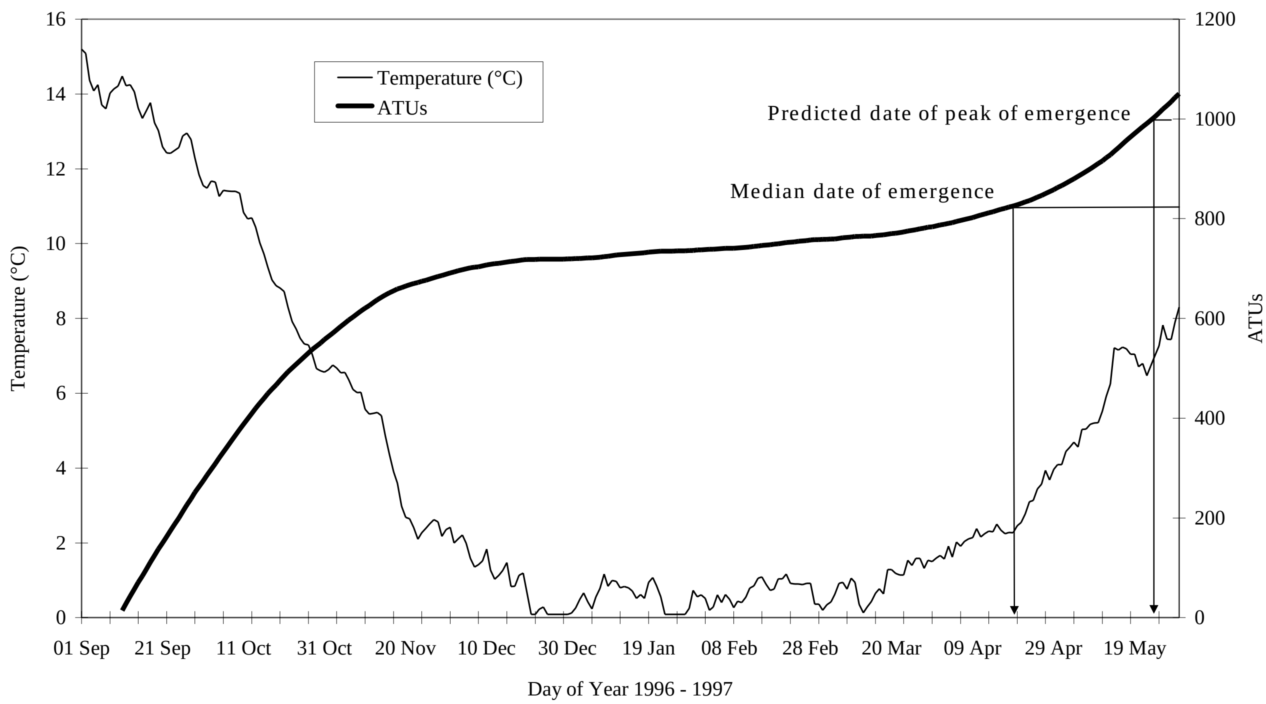


Figure 3
Discharge as Recorded at Skins Lake Spillway and in the Nechako River
Below Cheslatta Falls from March 1 to May 31, 1997

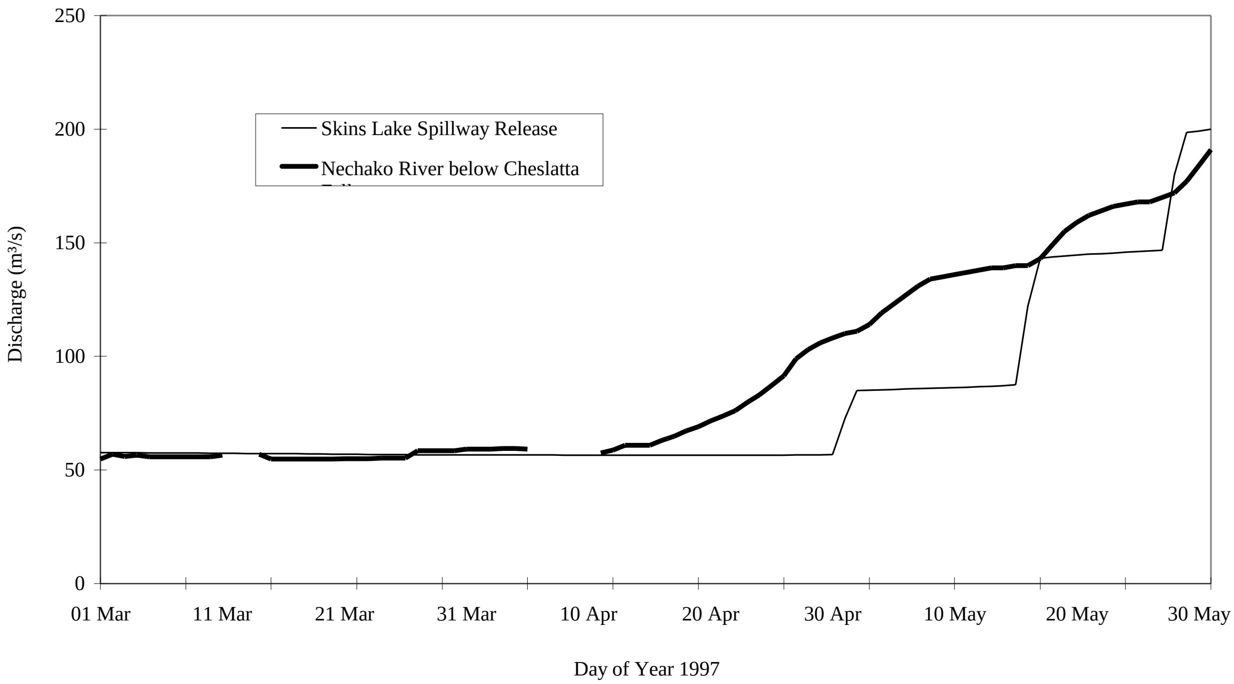


Table 1
Summary of Inclined Plane Trap Catches of Chinook 0+, and the Percentage Contributed
by Each Trap to the Total Catch at km 19 of the Nechako River, March 8 to May 20, 1997

Trap Number	Total	Night (morning check) Number	Night (morning check) Percentage	Day (evening check) Number	Day (evening check) Percentage	Percentage of catch Night	Percentage of catch Day	Percentage of catch Overall
1	6,001	5,547	16.7%	454	1.4%	17.6%	25.3%	18.0%
2	2,988	2,775	8.3%	213	0.6%	8.8%	11.8%	9.0%
3	3,545	3,342	10.0%	203	0.6%	10.6%	11.3%	10.7%
4	20,734	19,806	59.5%	928	2.8%	62.9%	51.6%	62.3%
Total	33,268	31,470	94.6%	1,798	5.4%	100.0%	100.0%	100.0%

Figure 4
Number of Chinook 0+ Enumerated Per Day and Night in all Inclined Plant Traps at km 19 in Reach 2 of the Nechako River, March 7 to May 20, 1997

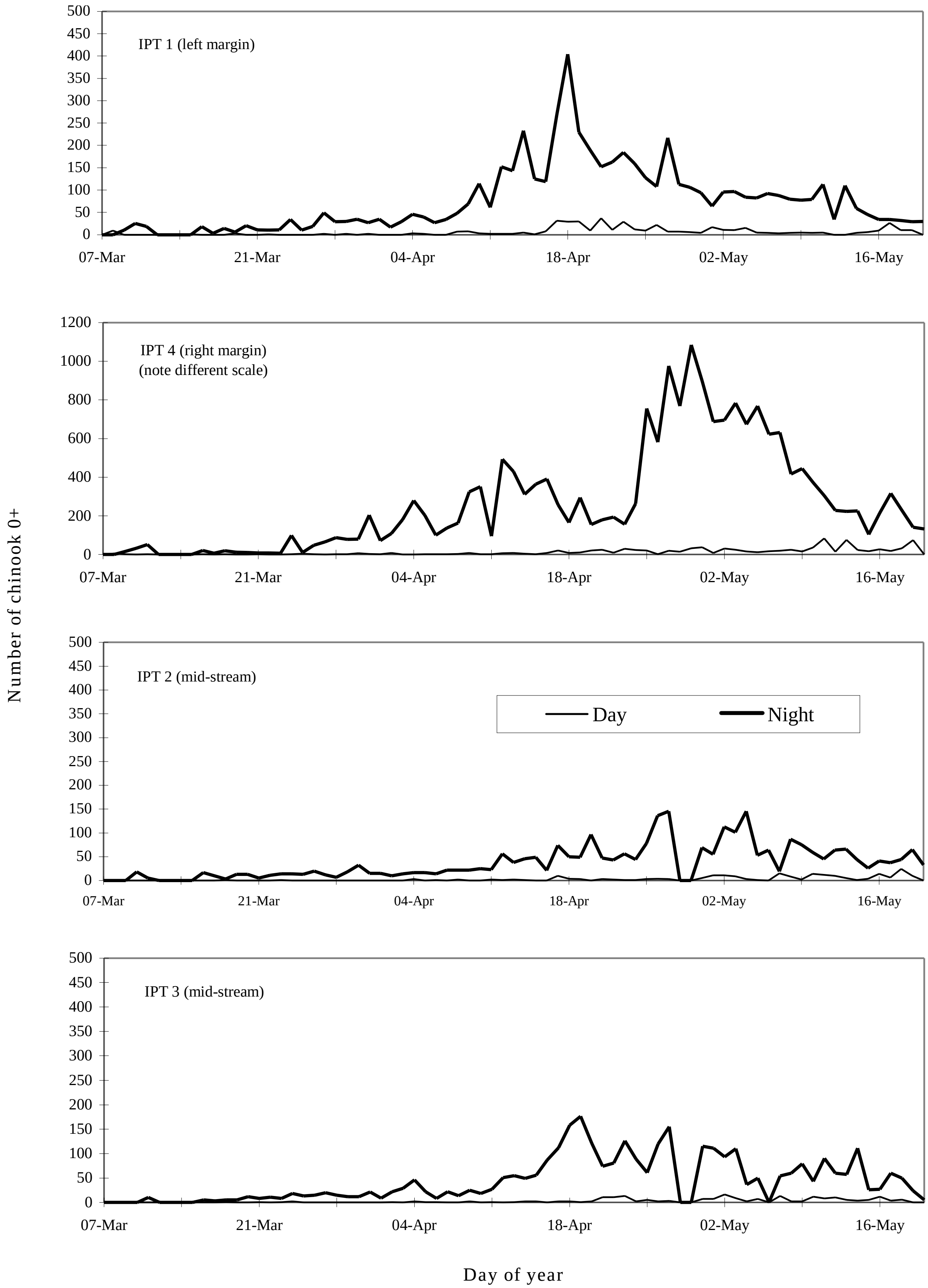
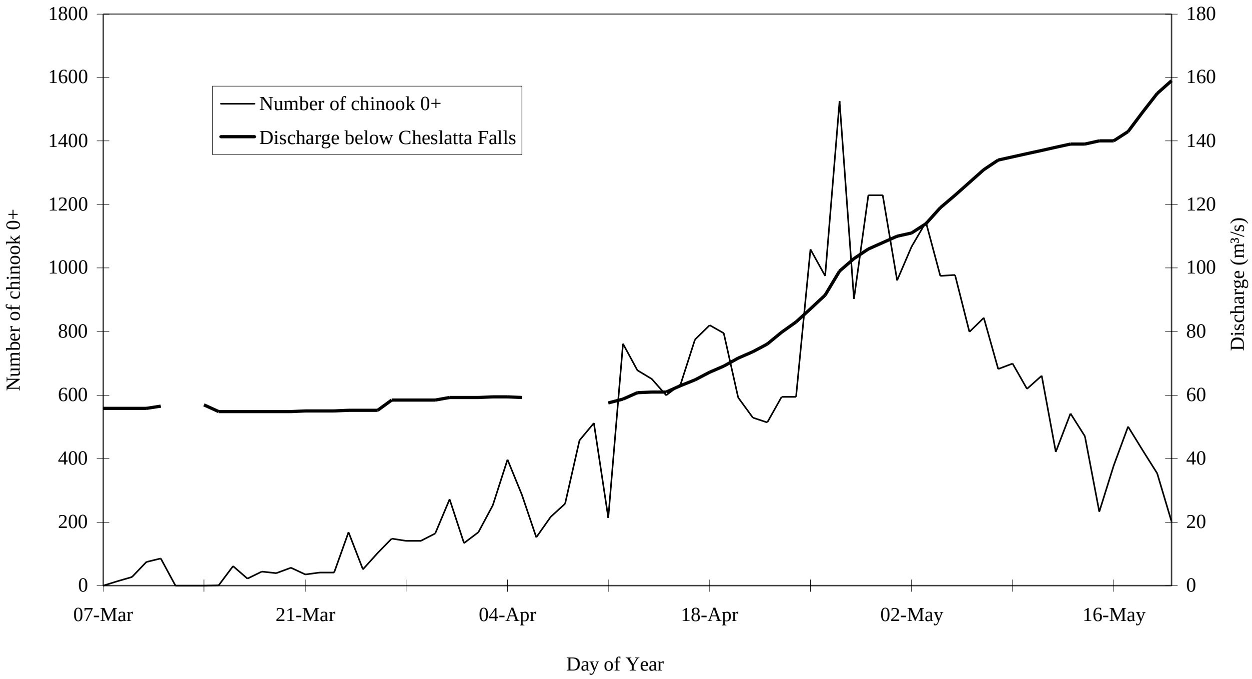


Figure 5
Discharge as Recorded Below Cheslatta Falls and Total Number of Chinook Fry Enumerated by Four IPTs at km 19 of the Nechako River, March 7 to May 20, 1997



The index of emergent fry moving past of the IPTs during the trapping period was estimated from the number of fry counted and the percentage of the flow sampled (Appendix 1). The date at which post-emergent fry started to make a significant contribution to the number of fry caught in the IPTs was inferred from examination of the variance in wet weight. The variance of wet weights pooled over time in 1997 did not increase significantly until May 18 (variance ratio test, Figures 6 and 7). The estimated daily index was therefore multiplied by the proportion of newly emerged fry, 68 %, only on May 19 and 20. The index of fry emergence calculated for each IPT ranged from 495,599 to 371,584 for IPTs 1, 2, and 3, but was 3,308,048 for IPT 4. The weighted total for all IPTs was 1,211,894 chinook fry. Figure 8 shows the daily index of fry emergence and the daily discharge.

Index of Fry Emergence and Trap Efficiency

Mark-recapture experiments show that the efficiency of all four IPTs combined decreased over the season from 4.5% to 0.5%, for an estimated population varying from 737,071 to 6,794,989 (Table 2). This last figure is likely an overestimate, due to the low efficiency. The average trap efficiency for all three releases (2.6%) translated into an estimated population of 783,126 fry (weighed estimate). The number of days marked fish were recaptured also declined over the sampling period. There was no significant difference between these estimates of chinook fry population and the indices of emergent fry determined from each IPT ($t_{0.05,4,3}$ = 0.673, P = 0.55).

Emergence Success

A total of 2,040 chinook salmon were estimated to have spawned in the Nechako River in 1996 (Unpublished, DFO), out of which approximately 20.4% (416) spawned upstream of the trapping site. Assuming a 1:1 sex ratio, 208 females were estimated to have deposited approximately 1,199,952 eggs (based on an average fecundity of 5,769 eggs per female, Jaromevic and Rowland (1988), Nechako River chinook). In previous years this calculation has resulted in an emergence success ranging from 42.2 % in 1991 to 56.7 % in 1995.

The emergence success for each IPT ranged from 41.3 % to 52.2 % for IPTs 1,2 and 3, and was 275.7% for IPT 4. The 1997 combined index of 1,211,849 resulted in a 101 % emergence success, clearly an over-

Figure 6

Mean Daily Development Index, Wet Weight and Fork Lengths of Juvenile Chinook Subsampled in IPTs at km 19, Nechako River, 1997, as a Function of Sampling Date

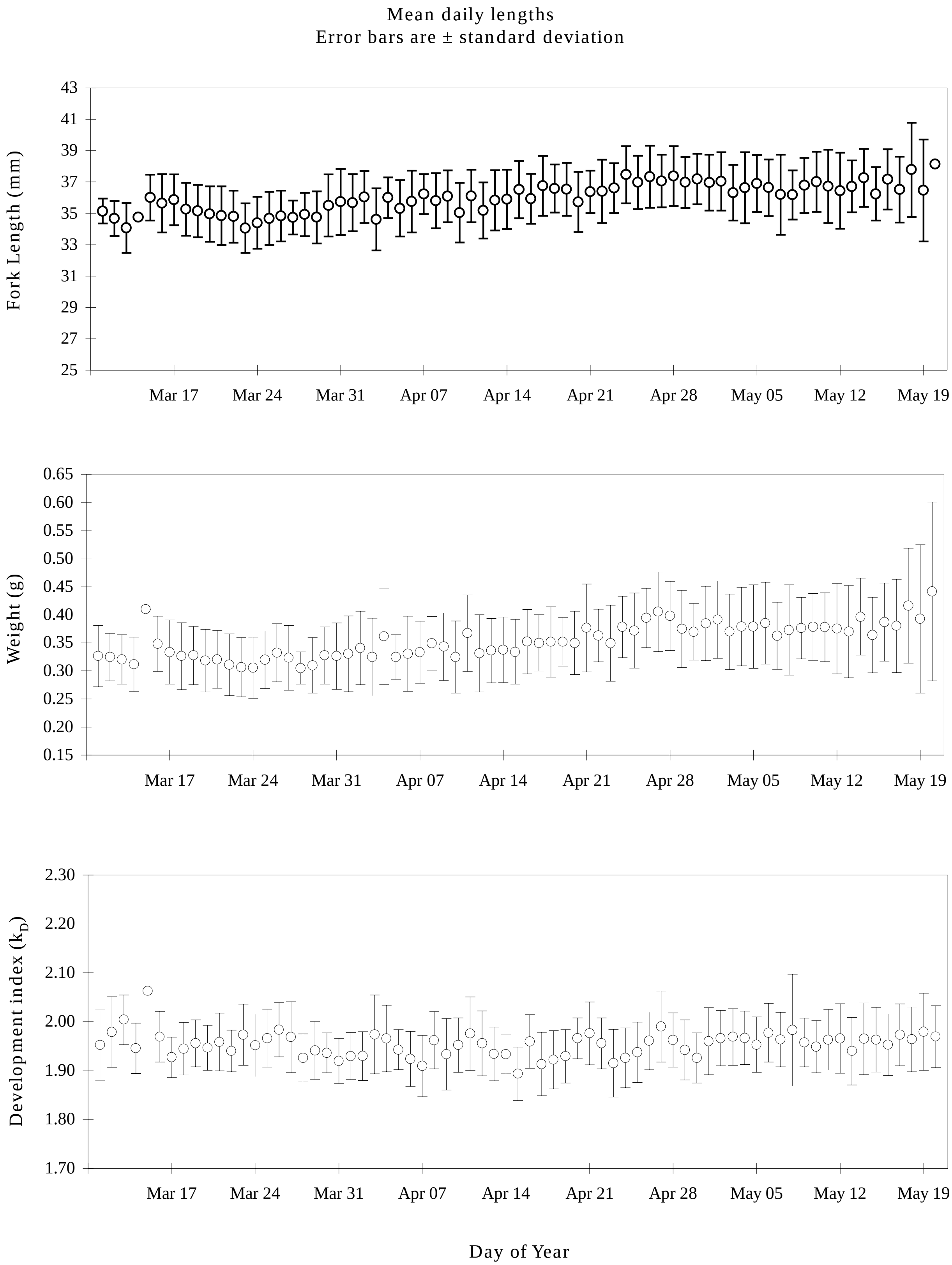


Figure 7
Standard Deviation (SD) of Juvenile Chinook Wet Weight as a Function of Date of Enumeration at IPTs at km 19, Nechako River, March 8 to May 20, 1997

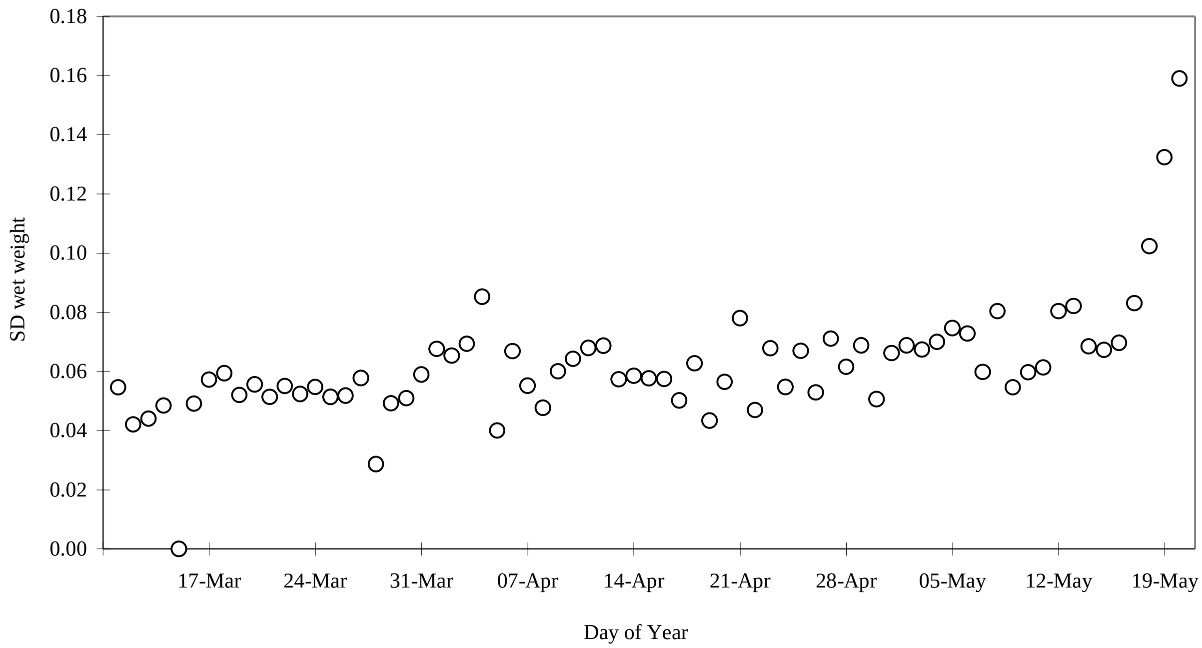


Figure 8
Discharge as Recorded Below Cheslatta Falls and Estimated Number of Chinook Fry from the IPTs at km 19 of the Nechako River, March 7 to May 20, 1997

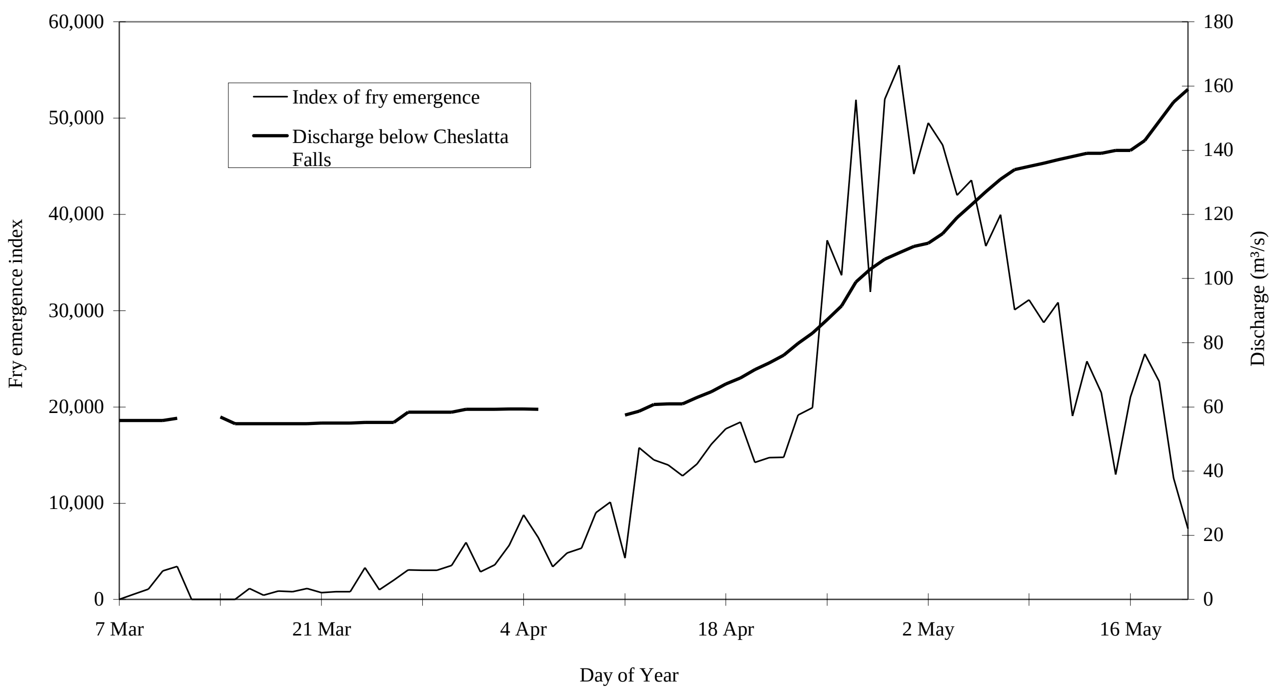


Table 2
Summary of Mark Recapture Trials on Emergent Chinook Fry at km 19.
Data for all four IPTs combined.

Release	Release date	Number released	Number of days fish caught	Number of recaptures	Trap efficiency (# recaptured/ # released)	Total catch	Estimated population (total catch / trap efficiency)
1	Apr 07	997	8	45	4.5%	33,268	737,071
2	May 02	3,000	3	125	4.2%	33,268	798,432
3	May 11	3,268	1	16	0.5%	33,268	6,794,989
Overall		7,265		186	2.56%		

estimate. The mark recapture population estimates for trials with trap effiencies greater than 0.5% would result in emergence success ranging from 61 % to 66 %.

Relationship Between Escapement and Index of Abundance

The indices of abundance (estimated number of fry) obtained for the past seven years of the project were significantly correlated with the escapement the previous fall (Triton 1997a, 0.96, $P<0.001$ (Pearson correlation)). The 1997 index is much higher than would be expected from the number of spawners estimated (Figure 9).

Morphological Data

Fork lengths, weights and development indices were not transformed in 1997 as the sample sizes were large and the distributions were near normal. Mean daily fork length, weight, and development index of chinook fry sampled during this project are presented in Appendix 2. The overall means and standard deviations for these morphological parameters are shown in Table 3. The results of factorial ANOVAs on the effects of time of day and trap position on chinook fry fork length, wet weight and development index are presented in Tables 4 to 6. There were significant effects of time of day for all variables and significant effects of trap position for wet weight and development index. No significant interaction between the two factors was detected. The effect of these factors on each variable is discussed in the following paragraphs. The average morphological parameters for emerging fry in each IPT during each sampling period are shown in Table 7.

Fork length: The interactions between trap position and time of emergence for fork length for all four traps are shown in Figure 10. There were no significant interactions between trap position and time of emergence, and there were no significant differences in the lengths of chinook fry sampled among the different traps ($P = 0.26$ and $P = 0.06$, Table 4) within either sampling period.

There were however significant differences in the lengths of fish sampled during the day and those sampled at night (t-test, $P <0.001$). Chinook emerging at night were on average 2.2 % shorter than those which emerging during the day. This difference was also observed in previous years (Triton 1997a), but may not be biologically significant.

Wet weight: The interactions between trap position and time of emergence for wet weight are shown in Figure 11. Although time of emergence and trap position both contributed significantly to the total explained variation observed ($P < 0.0001$, Table 5), the interaction between them did not ($P = 0.22$, Table 5). During the day, chinook 0+ from IPT 1 (left margin) were significantly heavier than those from any of the other traps (LSD, $P < 0.05$). At night, chinook 0+ from both margin traps (IPTs 1 and 4) were significantly heavier than those from both mid-channel traps (IPTs 2 and 3, LSD, $P <0.05$). There was also a significant effect of the time of emergence on the weight of chinook sampled, those sampled during the day being heavier than those sampled at night (LSD, $P < 0.05$). The percent difference from day to night ranged from 6.4 % for IPT 2 to 9.6 % for IPT 1.

Development Index: The interactions between trap position and time of emergence for K_D are shown in Figure 12. The interaction was not significant ($P = 0.79$)

Figure 9
Index of Fry Emergence Versus the Spawner Escapement Above km 19 of the Nechako River During the Previous Fall

Years are listed beside points.

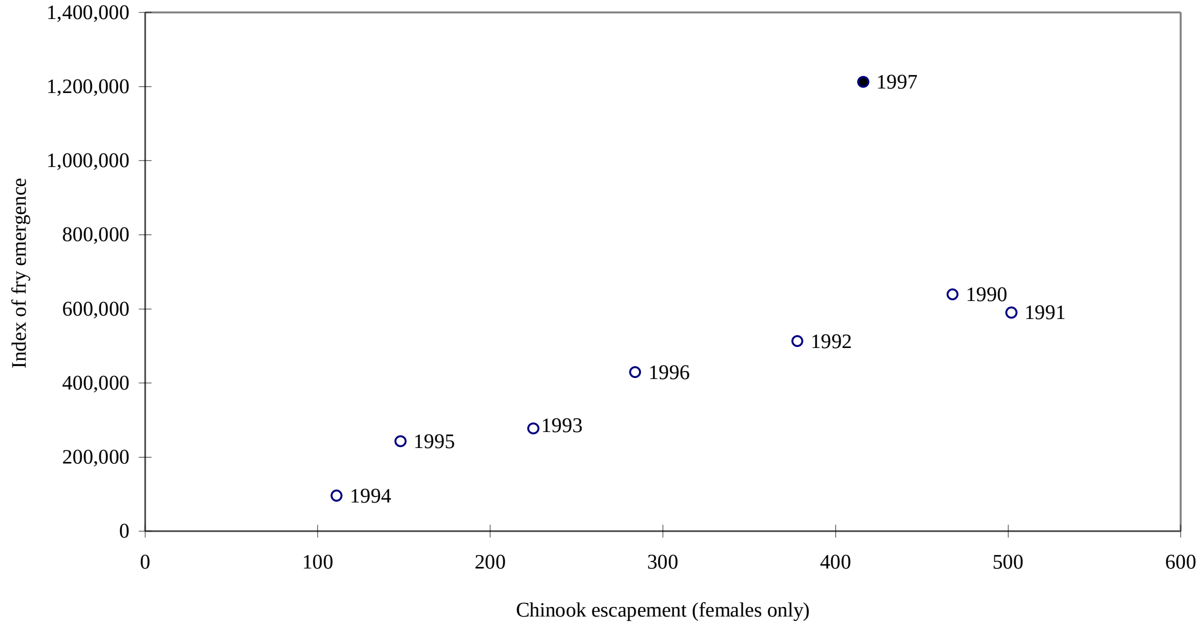


Table 3
Average Morphological Parameters for Emerging Chinook Enumerated in the IPTs at km 19, Nechako River, March 7 to May 20, 1997
N = 3,605

	Fork length (mm)	Wet weight (g)	K_D
Mean	36.2	0.36	1.95
Standard deviation	2.0	0.07	0.06

Table 4
ANOVA for Fork Length of Chinook Fry Sampled at km 19 of the Nechako River, 1997

Source of variation	Degrees of freedom	Mean square	F	Significance
Time of emergence	1	141.35	104.50	< 0.0001
Trap	3	9.84	2.48	0.06
Interaction	3	5.33	1.34	0.26
Explained	7	73.80	18.60	< 0.0001
Residual	3597	3.97		

Table 5
ANOVA for Wet Weight of Chinook Fry Sampled at km 19 of the Nechako River, 1997

Source of variation	Degrees of freedom	Mean square	F	Significance
Time of emergence	1	0.56	110.82	< 0.0001
Trap	3	0.03	6.61	< 0.0001
Interaction	3	0.01	1.48	0.22
Explained	7	0.11	22.20	< 0.0001
Residual	3597	0.01		

Table 6
ANOVA for Development Index of Chinook Fry Sampled at km 19 of the Nechako River, 1997

Source of variation	Degrees of freedom	Mean square	F	Significance
Time of emergence	1	0.06	15.58	< 0.0001
Trap	3	0.02	4.82	0.00
Interaction	3	0.00	0.34	0.79
Explained	7	0.03	5.89	< 0.0001
Residual	3597	0.00		

Table 7
Average Morphological Parameters for Emerging Fry in the IPTs at km 19 of the Nechako River, 1997

	Trap Number							
	1		2		3		4	
	Day	Night	Day	Night	Day	Night	Day	Night
N	302	681	180	608	175	589	391	679
Mean length (mm)	37.0	36.0	36.5	35.9	36.7	36.0	36.7	36.0
SE	0.121	0.080	0.120	0.086	0.138	0.079	0.095	0.076
Mean weight (g)	0.39	0.35	0.37	0.34	0.37	0.35	0.38	0.35
SE	0.005	0.003	0.005	0.003	0.005	0.003	0.004	0.003
Mean K_D	1.96	1.96	1.96	1.94	1.95	1.95	1.96	1.95
SE	0.004	0.003	0.005	0.002	0.005	0.002	0.003	0.002

Figure 10
Chinook Average Fork Length (± SE) at Each IPT as a Function of Time of Emergence

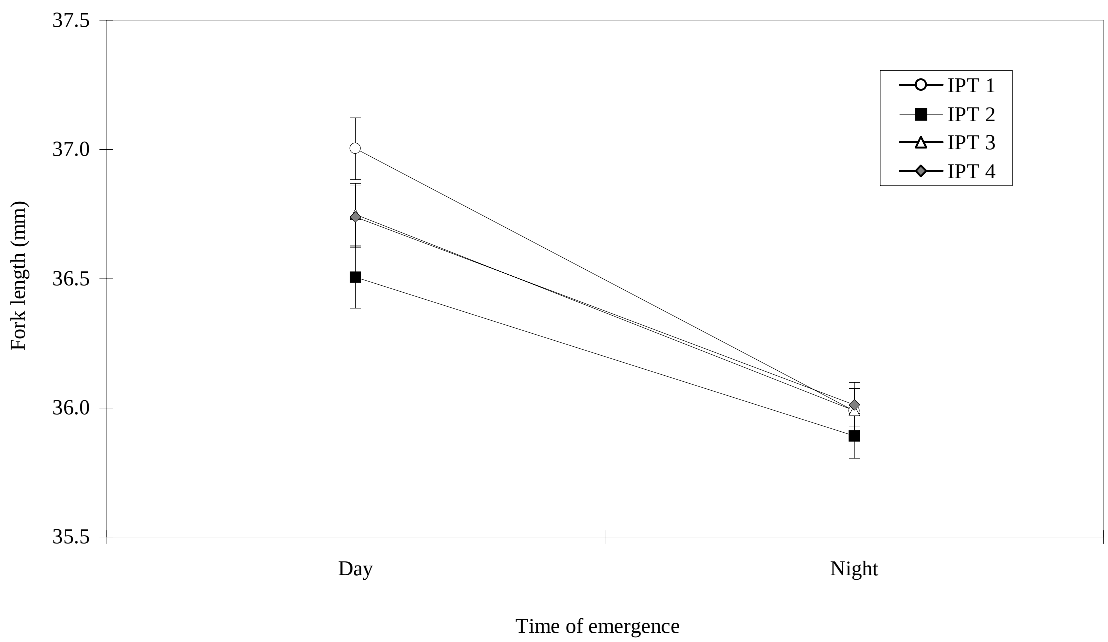


Figure 11
Average Wet Weight (± SE) of Juvenile Chinook at Each IPT as a Function of Time of Emergence

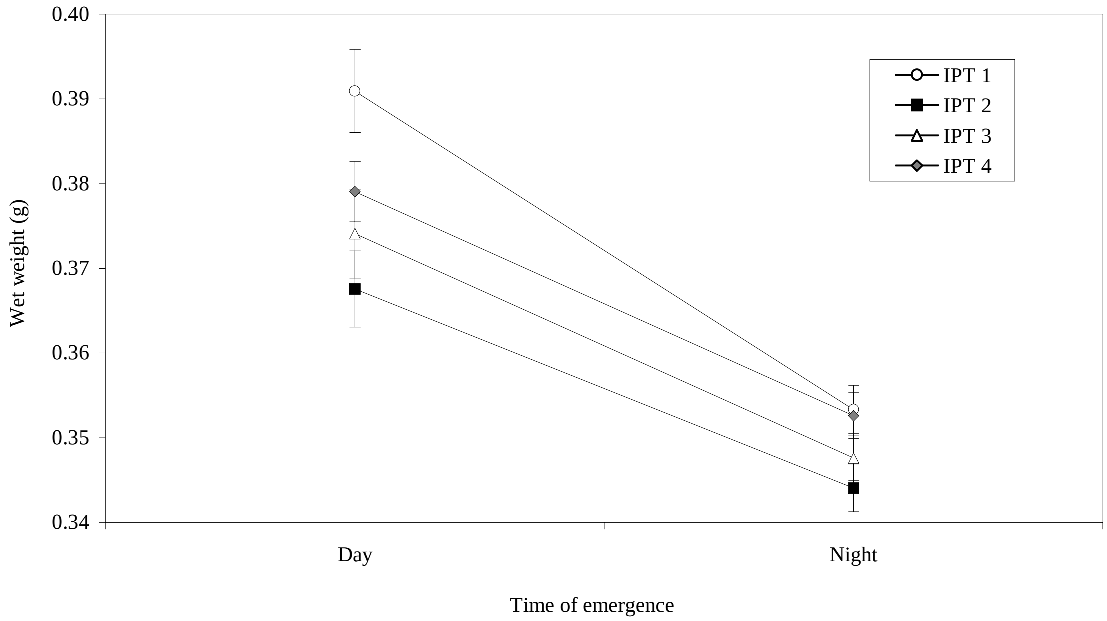
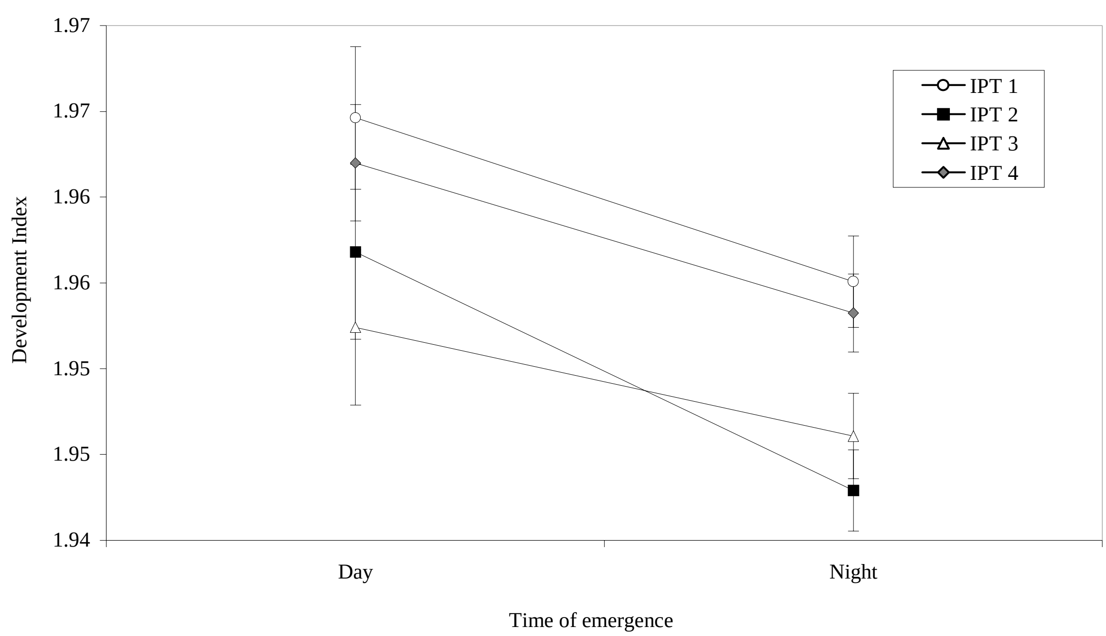


Figure 12
Mean Development Index (± SE) of Juvenile Chinook Enumerated at Each IPT as a Function of Time of Emergence



but both time of emergence ($P < 0.0001$) and trap position ($P = 0.002$) had significant effects on development index (Table 6). Chinook from IPTs 1 through 4 were not significantly different from one another during the day ($P = 0.23$) but at night chinook from IPTs 1 and 4 (margin traps) had significantly greater K_D than those from IPTs 2 and 3 (mid-channel traps) (LSD, $P < 0.05$).

Chinook emerging at night had, on average, a slightly lower development index than those which emerging during the day. For the margin traps (IPTs 1 and 4) the difference was 0.5%, and for the mid-channel traps (IPTs 2 and 3) the difference was 1.0 %.

The effect of sampling date on the biological variables was analyzed according to the groupings described above (Table 8). As in the previous year most of the regression lines had significantly positive but very small slopes which indicates that there had been little growth during the sampling period. This confirms that most fry sampled were emerging. The differences in fork length and in wet weight between fish caught at the start and end of the project were 5.9 % and 20.6 %.

Incidental Catch

The total incidental catch in 1997 was 2,590 fish, or 8 % of the total catch (Appendix 3). The percent composition of the incidental species and ranking of the species sampled in 1997 is compared with prev`ious years in Table 9. The percent of the total catch made up of incidental species was lower in 1997 than in previous years. Most of the incidental catch was taken at night (96.0 %) and in the margin traps (14.5 % in IPT 1, 81.0 % in IPT 4). The most common fishes captured by the IPTs were longnose dace (*Rhinichthys cataractae*, 2.3 % of the total catch), redside shiners (*Richardsonius balteatus*, 1.7 %), and sockeye salmon (*Oncorhynchus nerka*, 0.8 %).

The trends in abundance of the eight most common species other than chinook in the last seven years are shown in Figures 13 (percent of incidental catch) and 14 (absolute numbers). Rocky mountain whitefish (*Prosopium williamsoni*) numbers peaked in 1992 and in 1995. Northern pikeminnow (*Ptychocheilus oregonensis*) showed a sharp decrease in abundance from 1991 - 92 to 1993, and their numbers appear to have stabilized at this lower value in the last five years. The redside shiner catches declined from 1991 - 1993, and have been increasing each year since. Sockeye salmon counts peaked in 1992 - 1993, and similar counts were observed in 1997. Longnose dace counts had a sharp peak in 1994, but show fairly similar numbers for all other years. Largescale suckers (*Catostomus macrocheilus*) appear to have decreased in numbers from 1991, and sculpins (*Cottus sp.*) and leopard dace (*Rhinichthys falcatus*) numbers have not exhibited any trends over the last seven years.

DISCUSSION

The 1997 emergence was weakly bimodal, with peaks of emergence centered around April 18 and May 2, 1997 (Figure 5). This pattern was only observed in the actual catch and not reflected in the expanded catch. The timing of the peaks in actual catch is consistent with the peaks observed in 1995 (April 28 and May 2, Triton 1996) and 1996 (April 12 and May 11, Triton 1997a). The predicted period of peak emergence based on ATUs was May 24. The ATU values for the two peaks of emergence observed in 1997 were 823 (April 18) and 871 (May 2). The date when 50 % of all fry had been sampled (median date of emergence) was April 30 (860 ATUs). This is within the range of ATUs associated with the median dates of emergence for the past seven years (840 to 962, Table 10).

The index of estimated fry abundance in river sections 1, 2 and 3A (ie., at km 19) of the Nechako River for 1997 was 1,121,894 chinook (Appendix 1). This is the highest index yet calculated during the project (Table 11). The correlation between the number of spawners during the previous year and the total estimate of fry abundance has been very strong in the past seven years (Triton 1997a). However, the 1997 index was over twice as high as would be expected (Figure 9) from the number of spawners. The 1997 index of emergence success for the 208 female spawners estimated to have spawned above the study site is 101 %, in contrast to the values observed in the previous seven years which ranged from 42 % to 57 % (Triton 1997a).

Table 8
Parameters for the Regression Y = bx + a of Chinook Fry Measurements and Emergence Date for the 1997 Season, Where Y = Fork Length (FL), Wet Weight (Wt) or Development Index (K_D) and x - Emergence Date

Y	Time of emergence	Trap #	a	b	Adjusted R^2	P	N
FL	Day	all	-796.02	2.34E-02	0.034	< 0.01	1,048
	Night	all	-1284.59	3.72E-02	0.129	< 0.01	2,557
Wt	Day	1	-68.99	1.95E-03	0.127	< 0.01	302
		2,3,4	-30.22	8.61E-04	0.033	< 0.01	746
	Night	1,4	-42.66	1.21E-03	0.113	< 0.01	1,361
		2,3	-39.8	1.13E-03	0.105	< 0.01	1,196
K_D	Day	all	-22.06	6.76E-04	0.022	< 0.01	1,048
	Night	1,4	-0.811	7.78E-05	-0.00015	0.37	1,360
		2,3	1.086	2.41E-05	-0.00078	0.79	1,197

Table 9
Percent of Total Catch and Ranking of Incidental Species Caught in IPTs at km 19 of the Nechako River, 1991 - 1996

Species		Percent of total catch						
		1991	1992	1993	1994	1995	1996	1997
bull trout	*Salvelinus confluentus*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
burbot	*Lota lota*	0.12	0.00	0.00	0.01	0.00	0.00	0.00
Peamouth chubb	*Mylocheilus caurinus*	0.00	0.00	0.00	0.19	0.04	0.54	0.20
lake trout	*Salvelinus namaycush*	0.00	0.00	0.00	0.00	0.00	0.00	0.07
largescale sucker	*Catostomus macrocheilus*	2.69	2.11	3.11	4.02	3.52	2.09	0.50
leopard dace	*Rhinichthys falcatus*	0.73	1.63	0.75	7.24	3.06	4.07	0.54
longnose dace	*Rhinichthys cataractae*	3.78	2.97	3.23	21.85	4.29	4.24	2.34
mountain whitefish	*Prosopium williamsoni*	0.02	0.66	0.13	0.13	4.21	0.06	0.02
northern pikeminnow	*Ptychocheilus oregonensis*	4.26	1.84	1.68	1.17	1.64	1.41	0.63
rainbow trout	*Salmo gairdneri*	0.00	0.03	0.01	0.00	0.01	0.00	0.00
redside shiner	*Richardsonius balteatus*	4.32	2.54	0.78	3.57	3.12	3.26	1.69
sculpin	*Cottus sp.*	0.56	0.45	0.79	3.11	0.99	0.41	0.42
sockeye salmon	*Oncorhynchus nerka*	0.02	2.15	3.32	0.03	0.89	0.83	0.82
Total		16.49	14.40	21.50	41.37	21.76	16.93	7.22
		Ranking						
		1991	1992	1993	1994	1995	1996	1997
bull trout	*Salvelinus confluentus*	-	-	-	-	-	-	-
burbot	*Lota lota*	7	-	-	10	-	-	-
Peamouth chubb	*Mylocheilus caurinus*	-	-	-	7	9	7	8
lake trout	*Salvelinus namaycush*	-	-	-	-	-	-	9
largescale sucker	*Catostomus macrocheilus*	4	4	3	3	3	4	6
leopard dace	*Rhinichthys falcatus*	5	6	7	2	5	2	5
longnose dace	*Rhinichthys cataractae*	3	1	2	1	1	1	1
mountain whitefish	*Prosopium williamsoni*	8	7	8	8	2	9	10
northern pikeminnow	*Ptychocheilus oregonensis*	2	5	4	6	6	5	4
rainbow trout	*Salmo gairdneri*	-	9	9	-	10	-	-
redside shiner	*Richardsonius balteatus*	1	2	6	4	4	3	2
sculpin	*Cottus sp.*	6	8	5	5	7	8	7
sockeye salmon	*Oncorhynchus nerka*	10	3	1	9	8	6	3

Figure 13
Percent Composition of the Incidental Catch Made up by the Eight Most Common Species in the Last Seven Years of the Program

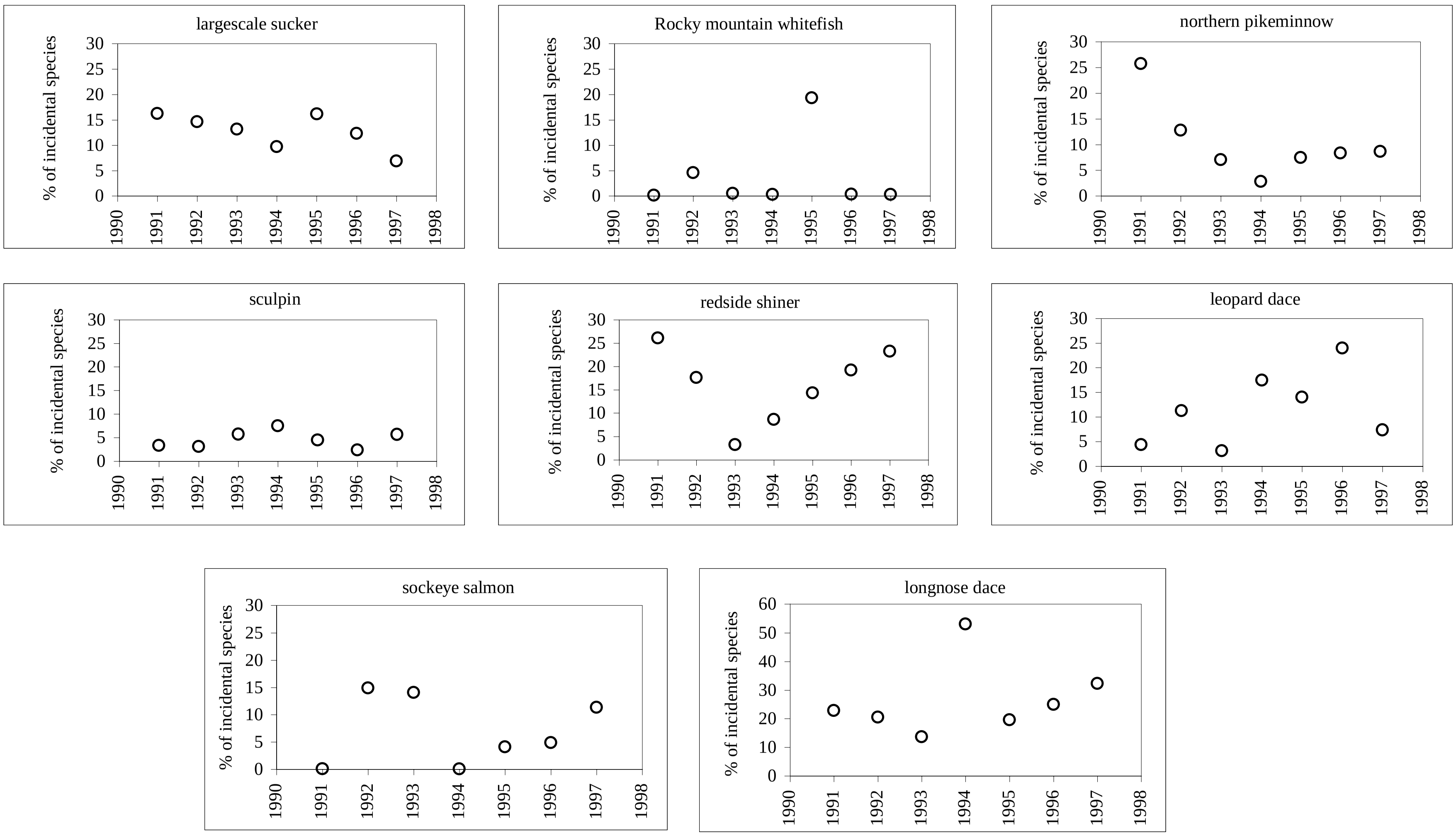


Figure 14
Composition of the Incidental Catch Made up by the Eight Most Common Species in the Last Seven Years of the Program

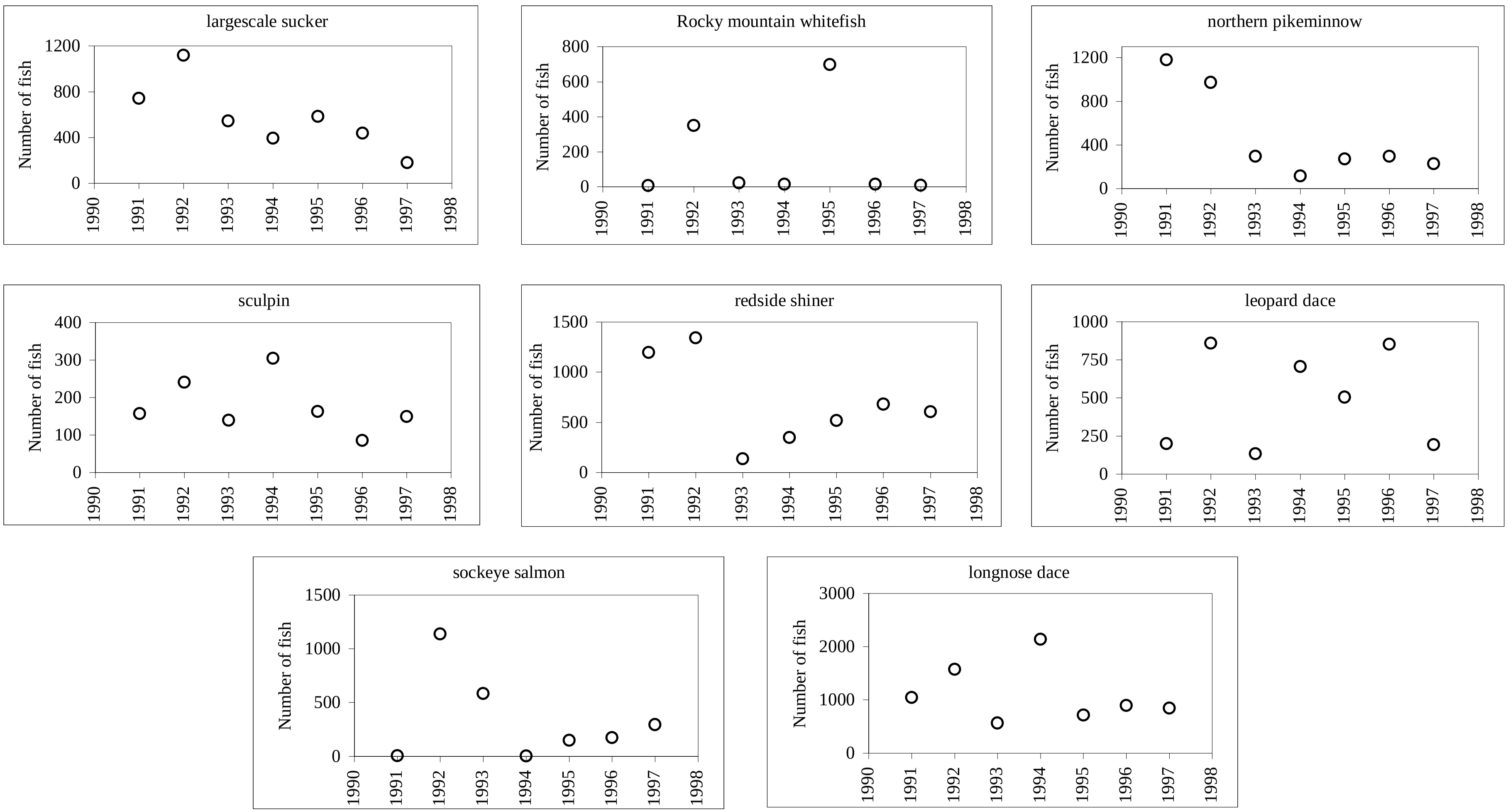


Table 10
Accumulated Thermal Units (ATUs) Recorded in the Nechako River at km 19 at the Time of 50% of Emergence (juvenile chinook captured in inclined plane traps) in the Last Eight Years of the Program

Year	Date of 50% of emergence	ATUs
1997	Apr-30	862
1996	May-06	849
1995	Apr-29	856
1994	Apr-15	962
1993	Apr-22	938
1992	Apr-19	903
1991	Apr-25	840
1990	Apr-13	935

Table 11
Variation in Index of Fry Emergence From Each IPT and From the Sum of Daily Weighted Estimates for All IPTs

Year	IPT 1	IPT 2	IPT 3	IPT 4	All IPTs combined	No. of spawners above km 19 (*)
1990		**			638,120	452
1991	378,617	670,612	518,816	1,473,604	589,456	482
1992	425,901	384,177	328,204	1,228,690	512,247	373
1993	161,526	273,008	241,908	742,405	276,613	225
1994	76,227	67,409	95,324	206,118	95,420	76
1995	173,493	113,270	186,960	718,951	242,058	149
1996	237,618	293,509	371,584	1,763,120	428,663	304
1997***	495,599	596,765	626,108	3,308,048	1,211,894	416

(*) number of spawners (females and males) during the preceeding year
(**) IPTs in different position
(***) forced spill flows approx. 3 times usual flows

There are two possibilities to explain this unusual number: either the number of spawners was underestimated or the index of emergent fry was overestimated in 1997. Given that the mark-recapture estimate fell within the range of previously observed values, the latter possibility appears more likely.

The fall of 1996 chinook spawner counts were conducted under high flow conditions which severely limited the visibility of the chinook in the river. This may have resulted in an underestimation of spawners above the study area. However, the estimated total escapement of chinook (2,040) was similar to the number expected from an examination of the escapement in 1992 and 1993 (brood years). The index of outmigrating chinook fry was consistent with the number of spawners observed (Triton 1997b). This further suggests that the index of fry emergence was overestimated in 1997.

The index is calculated by multiplying the number of fish sampled by each trap by the proportion of the discharge sampled by each trap. The assumptions incorporated into this calculation are that the traps sample the same proportion of the river flows regardless of the total discharge, and that the fry are randomly distributed within the water column. The relationship between the volume sampled by each trap and the total discharge of the Nechako River is shown in Figure 15. Clearly, the traps did not sample an increasing volume of water (hence not the same proportion) as the total discharge of the river increased.

This may be partly explained by higher flows creating a side channel, shifting the thalweg and changing the distribution of fry in the water column. The result may have been that flows and fry bypassed the traps.

Flows in the Nechako River in March 1997 were the highest recorded in seven years. They began to increase in April and continued to increase through to the end of the trapping project. By May 10, flows in the upper Nechako River were higher than during any previous sampling period since 1990 (Figure 16). As the flows increased, the proportion of the total flow in the river sampled by the IPTs decreased or remained stable, and the multiplier used to expand the index of emergent fry to account for the total flow in the river thus increased, resulting in an overestimate.

More fish were sampled by the right margin trap than in previous years. The proportion of the total number of fry caught in the right margin trap was 62%, while in

Figure 15
Relationship Between the Flows Sampled by the Four IPTs at km 19, and Flows in the Nechako River, 1997
Lines are best fits. Diagonal line is expected relationship under the assumption of proportional sampling.

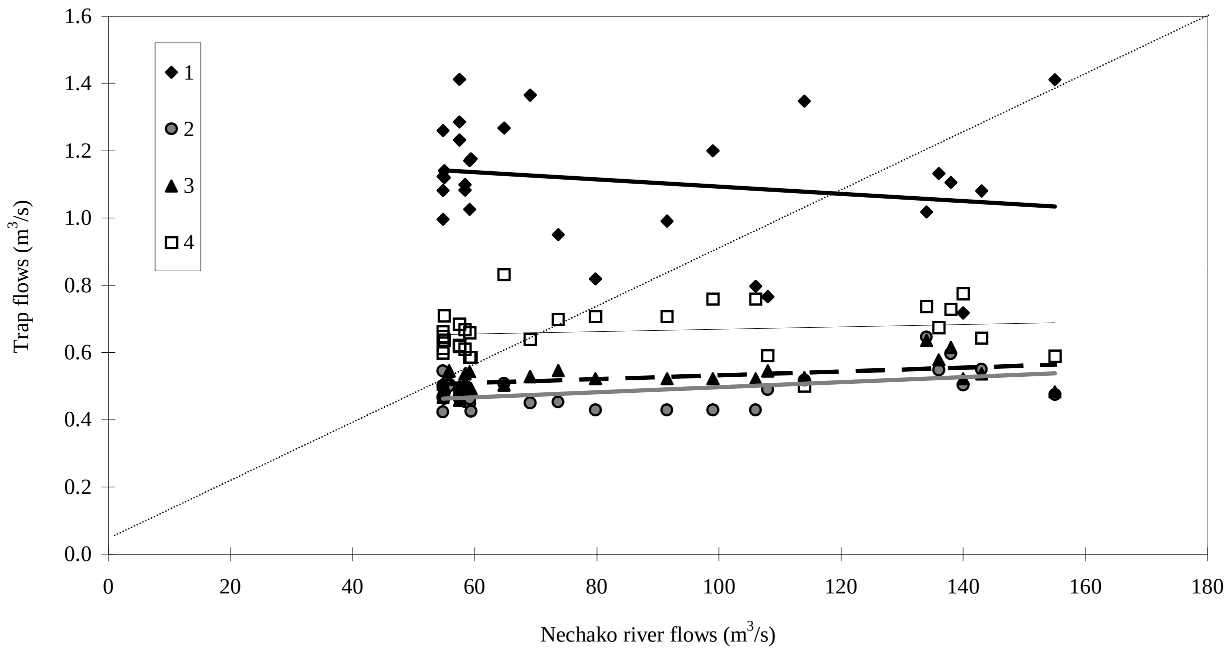
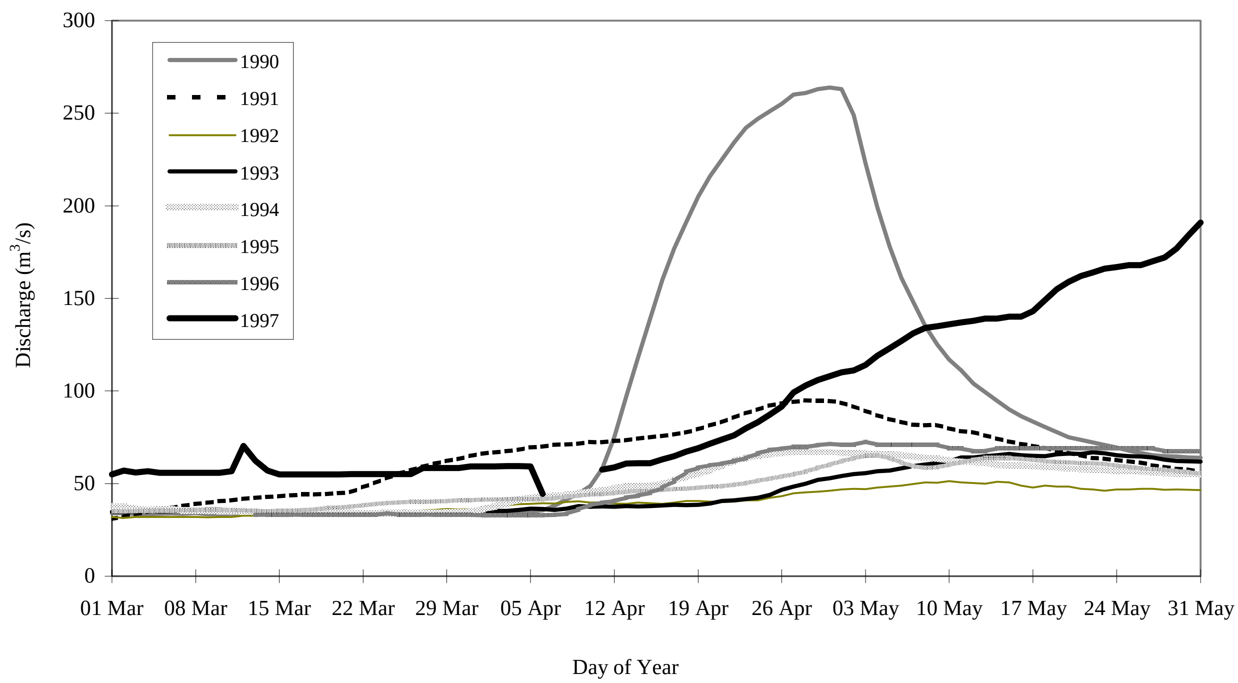


Figure 16
Mean Daily Discharge of the Nechako River Below Cheslatta Falls for the Period of March Through May, 1990 to 1997



previous years this number ranged from 20 to 45% (Table 12). The cross-sectional distribution of migrants appeared to be affected by flows, and an annual calibration for this effect and resultant weighting of catches may be necessary during years with more variable flows than have been experienced during the project.

In previous years of the study, flows during the sampling period have been consistent due to flow regulation, enabling between-year comparisons of the index of emergence. If the index is to be useful for making comparisons between years of more variable flow conditions, ways of testing these assumptions and improving the index will have to be developed.

Morphologically, emergent chinook measured in 1997 were very similar to emergent fish measured in previous years in terms of fork length, wet weight and development index (Figure 17). Generally, chinook sampled in the margin traps were heavier than those from the midstream traps (Table 7), which may indicate that these fish had already started feeding or that they spent less energy in movement (the flow velocity at the river margins was lower than in the middle). In addition, fish sampled during the day were also slightly heavier and longer than fish caught at night, particularly in the margin traps, indicating that they may have started feeding.

All regression lines of morphological parameters versus date had positive slopes (Table 8). The differences in fork length and in wet weight between start and end of the program (5.9 % and 20.6 %) were similar to those of 1996 (percent differences of 4.5 % and 23.2 % for fork length and wet weight wet respectively, Triton 1997a), and both were lower than the 1995 percent differences of 11.3 % and 71.4 % (Triton 1996). This may be attributable to the lower water temperatures experienced during the sampling periods in 1996 and 1997 (Figure 18), which could slow growth.

Incidental catch

The percent of the total incidental catch sampled by each IPT was different in 1997 than in previous years in that 81 % of fishes were caught in IPT 4, whereas in previous years that IPT's contribution to the incidental catch ranged between 41 and 67 %.

There was no significant difference in the contribution of incidental species between the years from 1991 to 1997 (Friedman Two-Way Anova, P = 0.22). Lake trout were caught for the first time (Table 9). They probably originated in Murray Lake and had been relocated by the forced spill.

The cycles and trends observed in the absolute numbers captured and the percent contribution to the incidental catch for mountain whitefish, redside shiners and northern pikeminnow in 1996 (Triton 1997a) continued in 1997. Overall, salmonids other than chinook (lake trout, Rocky mountain whitefish, sockeye salmon) accounted for 0.9 % of the total catch and for 12.9 % of the incidental catch. These values are similar to the 1996 values (0.9 % and 5.4 %), and both 1996 and 1997 are lower than the 1995 values (5.1 % and 23.5 %).

CONCLUSIONS

The 1997 fry emergence project continued to monitor the incubation environment of the river. The calculated index of fry emergence, although higher than predicted by the number of female spawners the previous year, nevertheless appeared to reflect the biological processes as evidenced by the relationship between the spawners and the index in all years but the high flow years. The trends, from index of fry emergence to morphological characteristics of emerging fry, indicate that the incubation environment in the Nechako River has been stable over the period of 1991 to 1997. The 1997 results imply that the quality of the incubation environment in the upper Nechako River does not show any degradation from previous years.

Table 12
Number of Fry Enumerated by Inclined Plane Traps at Bert Irvine's Lodge,
Nechako River, 1990 1997, and Percent of the Total Catch Enumerated by Each Trap

	IPT 1		IPT 2		IPT 3		IPT 4		
	Actual Catch	Percent of Total Catch	Actual Catch	Percent of Total Catch	Actual Catch	Percent of Total Catch	Actual Catch	Percent of Total Catch	Total Catch
1990	3,250	30.5	1,553	14.6	3,710	34.8	2,149	20.2	10,662
1991	9,382	40.9	4,245	18.5	2,816	12.3	6,503	28.3	22,946
1992	21,423	47.4	4,026	8.9	3,606	8.0	16,134	35.7	45,189
1993	3,845	25.5	2,919	19.3	2,643	17.5	5,697	37.7	15,104
1994	2,303	40.2	627	11.0	813	14.2	1,982	34.6	5,725
1995	4,549	35.1	1,167	9.0	1,776	13.7	5,450	42.1	12,942
1996	6,194	29.6	2,247	10.7	3,079	14.7	9,402	44.9	20,922
1997	6,001	18.0	2,988	9.0	3,545	10.7	20,734	62.3	33,268

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Figure 17
Average Fork Length, Wet Weight and Development Index of Emerging Juvenile Chinook Captured in Inclined Plane Traps in the Nechako River at km 19

Error bars are SD. Fish sampled up to and including cut-off date.

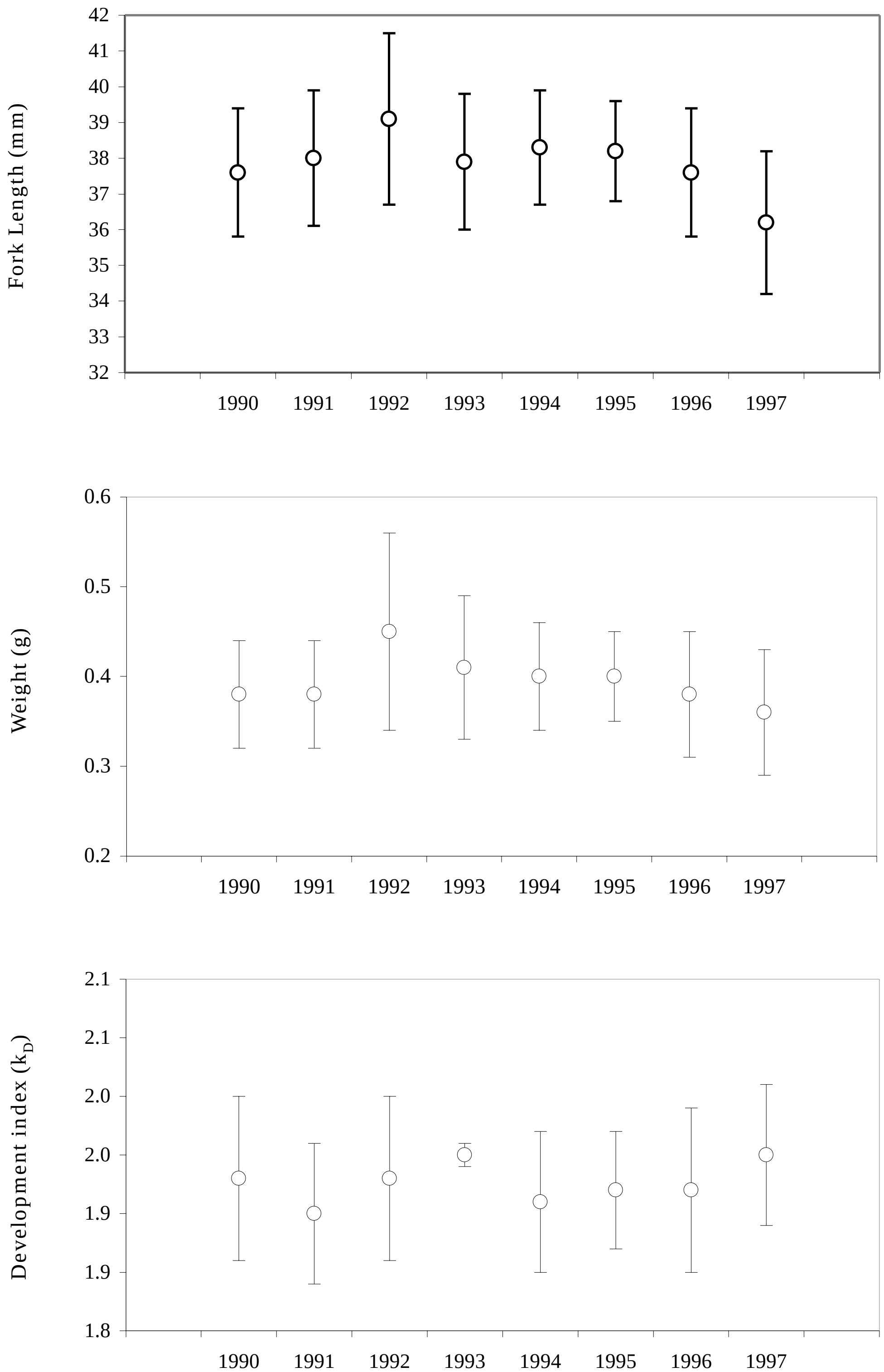
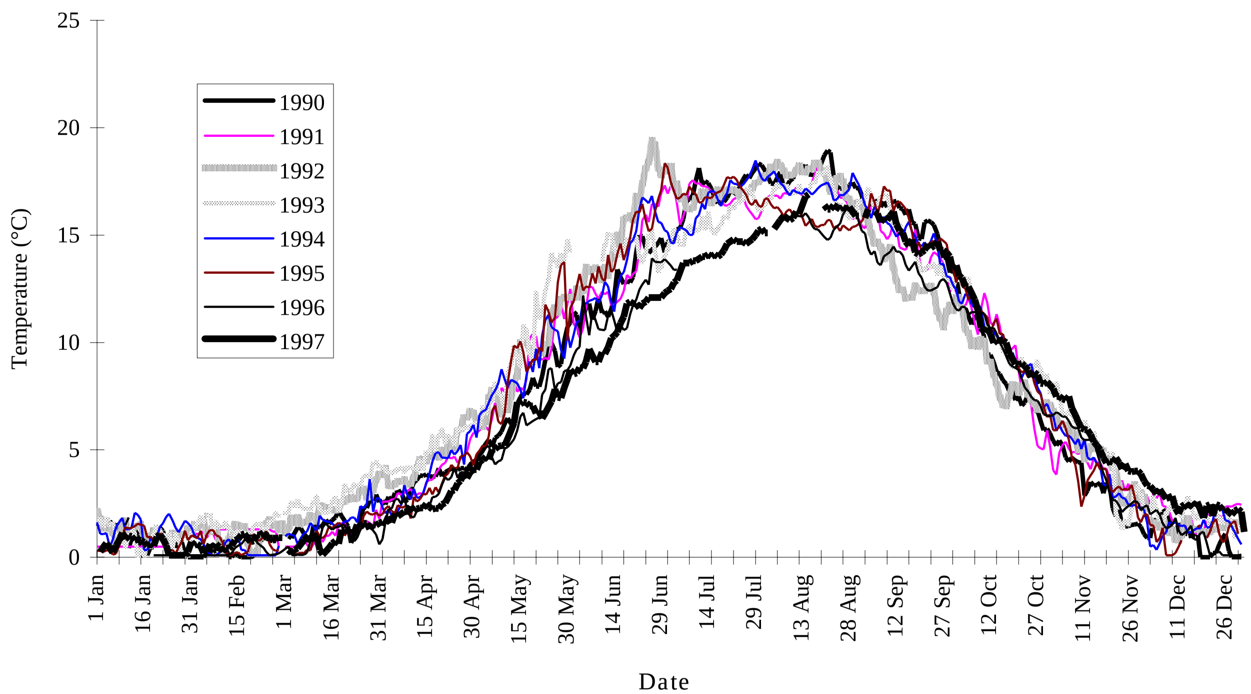


Figure 18
Mean Daily Water Temperatures at Bert Irvine's Lodge, km 19 of the Nechako River 1990 - 1997



APPENDIX 1
Estimates of the Numbers of Emerging Chinook Fry Enumerated at km 19 (Bert Irvine's Lodge), 1997

APPENDIX 2

Mean Fork Length, Wet Weight and Development Index (K_D) for Chinook 0+ Measured at IPTs at Bert Irvine's Lodge, km 19 of the Nechako River, 1997

Appendix 2
Mean Fork Length, Wet Weight and Development Index (K_D) for Chinook 0+ Measured at IPTs at Bert Irvine's Lodge, km 19 of the Nechako River, 1997

		Fork Length (mm)		Wet Weight (g)		K_D	
Date	N	Mean	SD	Mean	SD	Mean	SD
08-Mar	14	35.14	1.41	0.33	0.05	1.95	0.07
09-Mar	21	34.67	0.80	0.32	0.04	1.98	0.07
10-Mar	30	34.07	1.11	0.32	0.04	2.00	0.05
11-Mar	36	34.75	1.59	0.31	0.05	1.95	0.05
15-Mar	1	36.00	na	0.41	na	2.06	na
16-Mar	36	35.64	1.46	0.35	0.05	1.97	0.05
17-Mar	22	35.86	1.86	0.33	0.06	1.93	0.04
18-Mar	31	35.26	1.61	0.33	0.06	1.94	0.05
19-Mar	34	35.15	1.69	0.33	0.05	1.96	0.05
20-Mar	40	34.95	1.66	0.32	0.06	1.95	0.05
21-Mar	34	34.85	1.76	0.32	0.05	1.96	0.06
22-Mar	39	34.79	1.87	0.31	0.06	1.94	0.04
23-Mar	36	34.06	1.66	0.31	0.05	1.97	0.06
24-Mar	43	34.40	1.59	0.31	0.05	1.95	0.06
25-Mar	44	34.68	1.65	0.32	0.05	1.97	0.06
26-Mar	41	34.83	1.69	0.33	0.05	1.98	0.06
27-Mar	42	34.74	1.62	0.32	0.06	1.97	0.07
28-Mar	39	34.92	1.09	0.31	0.03	1.93	0.05
29-Mar	43	34.74	1.38	0.31	0.05	1.94	0.06
30-Mar	46	35.50	1.67	0.33	0.05	1.94	0.04
31-Mar	45	35.73	1.98	0.33	0.06	1.92	0.05
01-Apr	39	35.67	2.11	0.33	0.07	1.93	0.05
02-Apr	50	36.04	1.82	0.34	0.07	1.93	0.05
03-Apr	31	34.61	1.67	0.32	0.07	1.97	0.08
04-Apr	48	36.00	1.98	0.36	0.09	1.97	0.07
05-Apr	44	35.32	1.29	0.33	0.04	1.94	0.04
06-Apr	41	35.76	1.80	0.33	0.07	1.92	0.06
07-Apr	41	36.22	1.97	0.33	0.06	1.91	0.06
08-Apr	51	35.80	1.27	0.35	0.05	1.96	0.06
09-Apr	58	36.09	1.76	0.34	0.06	1.93	0.07
10-Apr	44	35.05	1.66	0.33	0.06	1.95	0.06
11-Apr	47	36.11	1.89	0.37	0.07	1.98	0.08
12-Apr	49	35.18	1.67	0.33	0.07	1.96	0.07
13-Apr	54	35.83	1.79	0.34	0.06	1.93	0.05
14-Apr	52	35.88	1.92	0.34	0.06	1.93	0.04
15-Apr	45	36.51	1.89	0.33	0.06	1.89	0.05
16-Apr	56	35.93	1.83	0.35	0.06	1.96	0.05
17-Apr	72	36.75	1.59	0.35	0.05	1.91	0.06
18-Apr	63	36.59	1.91	0.35	0.06	1.92	0.06
19-Apr	64	36.53	1.53	0.35	0.04	1.93	0.05
20-Apr	61	35.72	1.67	0.35	0.06	1.97	0.04
21-Apr	65	36.37	1.91	0.38	0.08	1.98	0.06
22-Apr	72	36.40	1.35	0.36	0.05	1.96	0.05
23-Apr	59	36.61	2.02	0.35	0.07	1.92	0.07
24-Apr	62	37.47	1.59	0.38	0.05	1.93	0.06
25-Apr	67	36.97	1.82	0.37	0.07	1.94	0.06
26-Apr	58	37.33	1.70	0.39	0.05	1.96	0.06

Appendix 2 (continued)
Mean Fork Length, Wet Weight and Development Index (K_D) for Chinook 0+ Measured at IPTs at Bert Irvine's Lodge, km 19 of the Nechako River, 1997

		Fork Length (mm)		Wet Weight (g)		K_D	
Date	N	Mean	SD	Mean	SD	Mean	SD
27-Apr	52	37.06	1.97	0.41	0.07	1.99	0.07
28-Apr	37	37.38	1.67	0.40	0.06	1.96	0.06
29-Apr	36	36.97	1.90	0.38	0.07	1.94	0.06
30-Apr	66	37.18	1.63	0.37	0.05	1.93	0.05
01-May	75	36.96	1.61	0.38	0.07	1.96	0.07
02-May	80	37.04	1.78	0.39	0.07	1.97	0.06
03-May	77	36.31	1.85	0.37	0.07	1.97	0.06
04-May	65	36.63	1.76	0.38	0.07	1.97	0.05
05-May	63	36.90	2.28	0.38	0.07	1.95	0.06
06-May	44	36.64	1.82	0.39	0.07	1.98	0.06
07-May	73	36.19	1.81	0.36	0.06	1.96	0.06
08-May	64	36.17	2.55	0.37	0.08	1.98	0.11
09-May	59	36.78	1.57	0.38	0.05	1.96	0.05
10-May	64	37.02	1.75	0.38	0.06	1.95	0.05
11-May	73	36.73	1.92	0.38	0.06	1.96	0.06
12-May	73	36.44	2.33	0.38	0.08	1.97	0.07
13-May	64	36.72	2.43	0.37	0.08	1.94	0.07
14-May	58	37.26	1.65	0.40	0.07	1.97	0.07
15-May	47	36.23	1.84	0.36	0.07	1.96	0.07
16-May	79	37.16	1.70	0.39	0.07	1.95	0.06
17-May	70	36.51	1.92	0.38	0.08	1.97	0.06
18-May	76	37.78	2.10	0.42	0.10	1.96	0.07
19-May	65	36.46	3.01	0.39	0.13	1.98	0.08
20-May	35	38.14	3.26	0.44	0.16	1.97	0.06

APPENDIX 3
Summary of 1997 IPT Catches by Month and Trap Number